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Assessment of Atlantic Salmon of the Saint John River, N.B., 1987

by

T.L. Marshall
Biological Sciences Branch
Department of Fisheries and Oceans
P.O. Box 550
Halifax, N.S.
B3J 2S7

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ABSTRACT

Estimated total returns to the Saint John River in 1987 were about 17,100 1SW and 8,000 MSW salmon. Homewater removals of about 3,500 1SW and 2,300 MSW fish led to an estimated 1987 spawning escapement only 57 percent of the target number of MSW spawners. The forecast of 1988 homewater returns is about 14,800 1SW fish (7,200 more than the target escapement) and 15,200 MSW salmon (5,100 fish more than the target escapement plus hatchery broodstock requirements). Homing tendencies of the MSW salmon will result in a surplus to spawning requirements of about 3,600 fish above Mactaquac. There will be a surplus of MSW fish to spawning escapement below Mactaquac of about 1,500 fish. Variation between forecasts and 'actual' fish returns continues to suggest the utility and value of multi-year management plans based on general trends in stock status rather than on a specific assessment.

RESUME

Les remontées totales estimées dans la rivière Saint-Jean en 1987 ont été d'environ 17 100 saumons unibermarins et 8 000 saumons pluribermarins. Compte tenu des retraits d'environ 3 500 unibermarins et 2 300 pluribermarins de leurs eaux d'origine, on chiffre approximativement à 57 % seulement du nombre cible de reproducteurs pluribermarins les échappées de reproducteurs en 1987. Pour 1988, les prévisions de remontées dans les eaux d'origine s'établissement à environ 14 800 unibermarins (7 200 de plus que l'échappée cible) et 15 200 pluribermarins (5 100 de plus que l'échappée cible plus les besoins de géniteurs pour l'élevage). Les tendances au retour dans les eaux d'origine des pluribermarins se traduiront par un excédent d'environ 3 600 poissons par rapport aux besoins de géniteurs, en amont de Mactaquac. On aura aussi un surplus d'environ 1 500 géniteurs en aval de Mactaquac. L'écart entre les prévisions et les remontées réelles de poisson semblent confirmer l'utilité et la valeur des plans de gestion multi-annuels fondés sur les tendances générales du stock plutôt que sur une évaluation donnée.

INTRODUCTION

This document is background to the management of Atlantic salmon stocks of the Saint John River, New Brunswick, and, as such, documents data and analyses available to November 1987 relevant to stock status in 1987 and forecasts for 1988.

BACKGROUND

Physical attributes of the Saint John River drainage, salmon production area, barriers to migration, fish collection and distribution systems, the role of fish culture operations and status of the salmon stocks since 1970 have previously been described by Marshall and Penney (MS 1983), Penney and Marshall (MS 1984), and Marshall (MS 1984, MS 1985, MS 1987).

Forecasts made in 1986 (Marshall MS 1987) suggested that total 1987 homewater returns would number approximately 13,200 1SW and 18,000 MSW salmon. CAFSAC advised managers (CAFSAC Advisory Document 86/26) that for 1987 there would in total be 5,500 1SW and 7,400 MSW salmon surplus to spawning requirements, including a surplus of 1,300 MSW salmon returning to tributaries below Mactaquac.

The Management Plan for 1987 was almost identical to that of 1986 in that there was a total ban on homewater commercial fisheries, a prohibition on the retention of MSW salmon captured in the sport fisheries, the same open seasons for sport fishing, a 900-fish quota for the Indian Food Fishery at Kingsclear and a 150-fish license for the Oromocto Indian Band. Differences from 1986 were that the Kingsclear Indian Band appeared to operate more discretely and tributary sport fisheries were closed most of August because of low water conditions. The reduction of open commercial seasons in Newfoundland, 1984-1987, and closure of Nova Scotia commercial fisheries, 1985-1987, are reflected in homewater returns but have not yet invalidated MSW forecasts derived from an 18-year data set.

Tobique River discharges in June, July and August were the lowest of 32 years of record. Mean monthly discharges at Mactaquac for May, June, July, August, September and October were not the lowest of record, but were 0.18, 0.49, 0.71, 0.49, 0.67 and 0.71, respectively, of the 20-year means. April discharge was the second highest of record.

Sport fishing success on the main stem was apparently not impacted by discharge levels. Sport fishing on tributaries was termed "poor" through August and good-to-excellent where seasons extended to mid and late October.

In general, estimates of total returns, removals and required spawners in 1987 and forecasts for 1988 were determined in a manner similar to that of Marshall (MS 1987).

METHODS

Total River Returns

Total returns of 1SW and MSW salmon of both wild and hatchery origin from both above and below Mactaquac Dam consist of the summation of Mactaquac counts, estimated catches by the Kingsclear Indian Band located between the Mactaquac Dam and Mactaquac Fish Culture Station, estimated angling catches in the

mainstem area immediately below the Mactaquac Fish Culture Station, estimated by-catch and estimated returns to tributaries below Mactaquac Dam.

Mactaquac counts consist of those fish captured at the fish collection facilities at the Mactaquac Dam and at the smolt migration channel at the Mactaquac Fish Culture Station. The discontinuation in 1984 of clipping the adipose fin from smolts originating at Mactaquac Fish Culture Station has meant that the identification of 1SW and MSW returns in 1987 from 1-year smolts released at Mactaquac were dependent on fin erosion (principally dorsal fin) and on interpretation of patterns of freshwater growth on scales.

Estimates of removals by Kingsclear were obtained from federal sources. Relative exploitation rates for 1SW and MSW salmon of hatchery origin (previous tag recovery information) and proportions of hatchery and wild fish at the dam were used to apportion total removals into hatchery/wild and 1SW/MSW components.

By-catch was estimated to be 2% of the total 1SW and 5% of the total MSW river returns - values which approximate the mean estimates for the years 1981-1984. Subdivision into above/below and hatchery/wild components was assumed to be proportionate to their respective contributions to the total run.

The total 1SW angling catch from the main stem below Mactaquac was assumed to be 85% of that of 1986. Ten percent of the MSW catch (exploitation rate of 1SW fish applied to MSW returns to the fishery) was considered to have been removed from the spawning escapement either because of illegal retention or delayed release mortality.

Returns of wild salmon to tributaries below Mactaquac in 1987 were based on their proportionate contribution to the estimated total Saint John River returns 1970-1983, i.e., 0.48 for 1SW and 0.41 for MSW fish (App. 1). This method was used again because of the absence of sport data, especially for MSW fish, comparable to that of pre-1984. Hatchery returns from 1-year smolts released to tributaries below Mactaquac were calculated as the product of the number of smolts released and an adjusted return rate for fish released at Mactaquac. Adjustments to the Mactaquac return rates, 1984-1987, were necessitated when, in 1987, an unusually high number of tagged adults appeared at Mactaquac from smolts released in tributaries below Mactaquac (App. 2). Hatchery returns from undersize smolts (<12 cm) or parr released both at and below Mactaquac in 1985 could not be evaluated but were assumed to return to below Mactaquac at respective forecast rates of 0.0074 x 0.5 and 0.0074 (Marshall MS 1987). Forecasts of returns to Mactaquac from parr releases at Mactaquac are inappropriate, given that there were no age-2 freshwater among "hatchery" returns to Mactaquac (dorsal fin erosion) and that at time of smoltification (1 year after introduction) survivors were unlikely to be proximate to the Mactaquac site.

Total River Removals

Total removals include estimates of those fish to the Kingsclear and Oromocto Indian Reserves, mainstem sport fishery below Mactaquac, 80% of the 1986 recreational harvest (O'Neil et al. 1987) from the remainder of the system and the by-catch fishery. Additional removals include some fish; captured in the Mactaquac collection facilities and transferred to the Aroostook River, retained at Mactaquac for broodstock, mortalities encountered during collection-handling operations and sacrificed for analysis. For the most part, proportions

of 1SW/MSW and hatchery/wild were based on the proportions estimated for each production area.

Required Spawners

An accessible salmon-producing substrate of 12,261,000 m^2 above Mactaquac and 15,928,000 m^2 below, an assumed requirement of 2.4 eggs/m^2, a length-fecundity relationship ($\log_e$ Eggs = 6.06423 + 0.03605 Fork Length) applied to MSW and 1SW fish, 1972-1982, and the 1SW:MSW ratios in those years suggest that, on average, approximately 4,400 and 5,700 MSW fish are required above and below Mactaquac (Marshall and Penney MS 1983). Because 1SW fish normally contribute so few eggs (fewer than 5% females) a management philosophy limits 1SW requirements to that number which provided males for MSW females unaccompanied by MSW males, i.e., 3,200 above and 4,000 below (Marshall and Penney op. cit.).

Stock Forecasts

a) Above Mactaquac

i) 1SW Wild

The forecast of wild 1SW returns originating above Mactaquac was derived from a regression of total wild 1SW fish returning to the Saint John River which were produced above Mactaquac, 1973-1985, on adjusted (method in Penney and Marshall MS 1984, with data updates, App. 3, 4 and 5 this paper) egg depositions in the Tobique River, 1968-1969 to 1980-1981. Returns of 1SW fish originating above Mactaquac in 1986 (Marshall MS 1987) were changed in accordance with a finalization of values for the recreational catch and by-catch.

Egg depositions for the period 1980-1981 were adjusted in the same manner as Penney and Marshall (MS 1984) using freshwater age composition from 525 wild 1SW fish sampled at Mactaquac in 1987. Adjustment of the 1983 and 1984 egg depositions, principal contributors to 1SW returns in 1988, was done with the use of angular-transformed mean proportions for age 2:1 and age 3:1 1SW fish in the 1969 to 1982 year-classes.

To make multiplicative effects of environment, competition, variability in recruits etc. amenable to linear regression analysis, the natural logarithms of the observed values were used (Ricker 1975). The geometric mean (GM) Y resultant of the logarithmic relationship was converted to an arithmetic mean (AM) by the formula $\log_{10}(AM/GM) = 0.2172\ s^2\ (N-1)/N$, where s is the standard deviation from the regression line of the normally-distributed natural logarithms of the variates (Ricker 1975, p. 274).

ii) MSW Wild

The 1988 forecast of MSW returns to homewaters which originated above Mactaquac was based on the regression of the estimated MSW returns destined for Mactaquac, 1971-1987, on the estimated numbers of 1SW fish originating above Mactaquac returning to Saint John River in the previous year. Analysis included the use of natural logarithms and conversion of the GM to AM.

iii) 1SW Hatchery

The release in 1985, 1986 and 1987 of all 1-year smolts, as opposed to principally 2-year smolts 1967-1984, prevented the forecasting of 1SW or MSW hatchery returns by either the product of the long-term return rates and the number of smolts released or by regression technique. Instead, the return rate for 1SW fish in 1988 from 1987 1-year smolts released at Mactaquac was assumed to be the same as the mean (arcsin) of the adjusted 1986 and 1987 return rates. Tag returns at Mactaquac were used to derive a mean (arcsin) proportion of adults that would return to Mactaquac from smolts released in tributaries below (App. 2).

Additional 1SW returns are expected in 1988 to Mactaquac from fall fingerlings culled from the 1-year smolt program and released in tributaries above Mactaquac in 1985. The return rate was calculated as the product of an assumed 0.08 survival to age-2 smolt and a 0.03 smolt-to-1SW return rate.

iv) MSW Hatchery

Returns as MSW fish from 1-year smolts released at Mactaquac in 1986 were estimated as the product of their number and adjusted return rate for 1-year smolts released from Mactaquac in 1985. As with 1SW hatchery returns, MSW fish destined for below Mactaquac were proportioned to above and below destinations on the basis of tag returns 1985-1987 (App. 2). This alternative was instead of using the return rates of experimental lots tagged in 1976, 1978 and 1979 (Marshall MS 1987).

As well, returns are expected from unaccelerated fall fingerlings released above Mactaquac in 1984. Sixty percent were assumed to smoltify at age-3. Survival between time at stocking and smoltification was assumed to be 5%. The smolt-to-MSW return rate was assumed to be 0.025.

b) Below Mactaquac

i) 1SW Wild

The 1988 return to homewaters of 1SW fish which originated below Mactaquac was estimated from the forecast number of 1SW originating above Mactaquac and the proportion that the 1SW fish from below Mactaquac were of the total 1SW river returns, 1970-1983. This proportion is greater (by 0.04) than the 1970-1985 value used by Marshall (MS 1987) and may more accurately represent the contribution by the area below Mactaquac. Use of this proportion is reflected in the revised estimates of returns in 1986 (App. 1).

ii) MSW Wild

The 1988 return to homewaters of MSW salmon which originated below Mactaquac was based on the forecast number of MSW fish originating above Mactaquac and the proportion that the estimated returns of MSW fish below Mactaquac were of the estimated total MSW returns to the river, 1970-1983. This proportion is greater (by 0.02) than the 1970-1985 value used by Marshall (MS 1987) and is reflected in the revised returns, 1986 (App. 1).

iii) 1SW Hatchery

Returns from 1-year smolts released below Mactaquac in 1987 were calculated as the product of their number and 0.75 of the estimated return rate for smolts released at Mactaquac. It was assumed that 0.25 of returns would stray to Mactaquac. Returns from 1-year parr released in parr habitat of tributaries below Mactaquac in 1986 were calculated as the product of their number and a 0.30 survival rate to smolt and a 0.025 return rate as 1SW fish.

Returns from 1-year parr released at Mactaquac were calculated in the same manner but discounted by 0.5 for the less-than-ideal habitat in the mainstem below Mactaquac.

Returns from fall fingerlings culled from the 1-year smolt program and placed in tributaries below Mactaquac in 1985 were calculated in the same manner as for fall fingerlings placed above Mactaquac. Unfed fry, 1985, were accorded a 0.01 survival rate with 60% smoltifying at age-2 and a smolt-to-1SW return of 0.025.

iv) MSW Hatchery

MSW returns from 1-year smolts released in 1986 to tributaries below Mactaquac were calculated in the same manner as for those returning to Mactaquac.

MSW returns from 1-year parr released at and below Mactaquac in 1985 were, with the exception of the 0.5 discount factor for mainstem introductions, estimated in the same manner. Parr-to-smolt survival was assumed to be 0.30 and the smolt-to-MSW return rate was assumed to be 0.025.

MSW returns from unaccelerated fall fingerlings released in 1985 were derived in the same manner as for releases above Mactaquac except that only 40% were assumed to have contributed to age-3 smolts.

RESULTS

Total River Returns

Estimated homewater returns in 1987 totalled 17,063 1SW fish (9,237 destined for above and 7,826 destined for below Mactaquac) and 8,037 MSW fish (4,832 destined for above and 3,205 destined for below Mactaquac; Table 1). Hatchery returns comprised 33% and 8% of the total 1SW and MSW returns, respectively.

Counts at Mactaquac were 86% of the 1SW and 71% of the MSW fish estimated to be destined for above Mactaquac (Table 1). The removal at Kingsclear was estimated at 1,400 fish comprised of approximately 280 1SW and 1,120 MSW salmon.

Releases of 56,992 and 38,387 hatchery smolts to tributaries below Mactaquac in 1985 and 1986 respectively, the adjusted 1987 return rates of 0.01570 and 0.00453 (Table 2), and releases in 1985 of 143,658 and 211,655 parr at and below Mactaquac, respectively, with 0.0074 x 0.5 and 0.0074 return rates suggest hatchery origin returns below Mactaquac in 1987 (Table 1) of 2,378 1SW and 181 MSW fish.

Total River Removals

Sport removals are extremely preliminary in nature; total river removals have been estimated at about 3,500 1SW and 2,300 MSW fish (Table 3).

Spawning Escapement

Collation of the total returns (Table 1), total removals (Table 3) and numbers of fish required to meet an egg deposition of 2.4 eggs/m^2 indicate that 63% and 52% of the required MSW spawners were attained above and below Mactaquac, respectively (Table 4). For 1SW fish, 219% of requirements were met above Mactaquac; 148% of requirements were met below Mactaquac.

The proportion of females among wild and hatchery 1SW fish counted at Mactaquac increased from 0.054 in 1986 to 0.077 in 1987. The proportion of wild 1SW females increased from 0.058 in 1986 to 0.107 in 1987. The 3,820 1SW fish surplus to spawning requirements above Mactaquac, however, are equivalent to fewer than 100 MSW fish or about 6 percent of the MSW deficit.

Stock Forecasts

a) Above Mactaquac

i) 1SW Wild

The 1988 forecast of wild 1SW fish returning to Mactaquac in the absence of homewater removals was based on the regression of returns to homewaters of 1SW fish which originated above Mactaquac on estimated Tobique River egg depositions adjusted for smolt age (Table 5). The AM estimate for 1SW returns in 1988 is 6,054 1SW fish (95% C.L. 4,748-7,719) (Table 5; Fig. 1).

ii) MSW Wild

The forecast of wild MSW fish destined for Mactaquac in 1988 was based on the regression $\log_e Y = 5.026 + 0.433 \log_e X$ (n=17; r=0.63; p= 0.007; Table 5; Fig. 2). The 5,909 1SW returns to Mactaquac in 1987 provided an AM estimate of 6,983 MSW fish (95% C.L. 5,649-8,631) destined for Mactaquac in 1988.

iii) 1SW Hatchery

The forecast of hatchery 1SW fish destined for Mactaquac in 1988 was in part calculated as the product of an estimated 113,439 1-year smolts released at Mactaquac and an adjusted 0.01193 return rate (Table 6), i.e., 1,353 fish. Another 118 would return from smolts placed below Mactaquac. In addition, it was estimated that 289,000 fall fingerlings released above Mactaquac in 1985 might experience a survival to 1SW return of 0.08 x 0.03, i.e., 694 fish (Table 6). The total forecast of hatchery 1SW returns to Mactaquac is 2,165 1SW fish.

iv) MSW Hatchery

MSW returns destined for Mactaquac in 1988 were calculated as the sum of the product of an estimated return rate of 0.00453 and 191,495 smolts released at

Mactaquac and 0.36 of returns from 38,387 smolts released below Mactaquac in 1986, and the product of 123,600 fall fingerlings released in 1984 and a survival/return rate of (0.05x0.6) x 0.025 (Table 6). The forecast of hatchery MSW returns to Mactaquac is 1,023 MSW fish (Table 6).

b) Below Mactaquac

i) 1SW Wild

Based on the 1970-1983 proportions of 0.52 of the total wild 1SW returns originating above Mactaquac and 0.48 originating below Mactaquac (App. 1) and the 1988 forecast of 1SW returns above Mactaquac, it is estimated that the number of wild 1SW fish below Mactaquac in 1988 will be 6,054/0.52-6054 or 5,588 1SW fish.

ii) MSW Wild

In a manner similar to that for forecasting 1SW fish below, MSW salmon below Mactaquac were estimated from the 0.59: 0.41 proportion for MSW fish above:below, 1970-1983. Hence the estimate is 6,983/0.59-6,983 or 4,853 MSW fish.

iii) 1SW Hatchery

The forecast of hatchery 1SW fish destined for tributaries below Mactaquac in 1988 was in part calculated as the product of an estimated 39,445 smolts released and 0.75 of the 0.01193 arcsin mean return rate for 1-year smolts in 1986-1987, i.e., 353 1SW fish (Table 6). In addition it was estimated that 89,115 and 14,337 parr released at Mactaquac and in parr habitat below Mactaquac would yield a total of 442 fish (Table 6). Fall fingerlings and unfed fry are expected to yield another 292 1SW fish (Table 6). Total 1SW hatchery fish returning to tributaries below Mactaquac are expected to number 1,087 1SW fish.

iv) MSW Hatchery

MSW hatchery returns below Mactaquac in 1988 were in part forecast as the product of 0.64, the estimated 0.00453 return rate and 38,387 smolts released in 1986, i.e., 111 MSW fish (Table 6). Returns from 143,658 and 211,665 parr released at and below Mactaquac are expected to yield another 539 and 1,587 MSW fish respectively. Fall fingerlings, i.e., 294,200 released below Mactaquac are expected to yield another 147 MSW fish (Table 6). MSW returns of hatchery origin below Mactaquac are expected to total 2,384 fish.

Forecast Summary

The forecast of total homewater returns (Table 7) to the Saint John River in 1988 is 14,830 1SW (11,642 of wild and 3,188 of hatchery origin) and 15,243 MSW fish (11,836 of wild and 3,407 of hatchery origin). For the total Saint John River the forecast returns minus the spawning requirements result in potential surpluses of 7,230 1SW and 5,143 MSW salmon. Separation to above- and below-Mactaquac origins indicates surpluses over target escapements of 5,019 1SW and 3,606 MSW salmon for the former and 2,211 1SW fish and only 1,537 MSW salmon for the latter.

DISCUSSION

Total estimated river returns in 1987 of 17,063 1SW and 8,037 MSW salmon were 129% and 45% of forecast returns. MSW returns incl. fish of hatchery origin were, in fact, the lowest since 1979 (App. 6; Fig. 3). Returns of wild 1SW fish above and below Mactaquac were 118% and 139%, respectively of forecasts; wild MSW fish above and below were 52% and 57% of the respective forecast values. Hatchery 1SW and MSW returns were 136% and 15% of forecasts. Despite the lowest removals since 1973 (App. 7), spawning escapement of MSW fish above Mactaquac was only 63% of requirement; escapement below was 52% of requirement.

The shortfall of MSW fish from a smolt class which had provided 1SW returns in 1986 in excess of all forecast levels cannot be explained at this time. Tagging data for Mactaquac smolts, 1975-1986, indicated that adjusted proportions of MSW tags returned from distant fisheries in 1986 (0.32) was similar to that of 1985 (0.34) and the long-term mean (0.33) (Ritter, pers. comm.). Shifting of would-be MSW fish to earlier maturing 1SW fish, as evidenced by an increase in the proportion of females among 1SW fish (Marshall et al. MS 1982) has not been illustrated for salmon of the Saint John River.

Total returns are however a function of the estimate of removals--a continuing shortcoming. Lack of timely quality angling data, especially for MSW fish below Mactaquac again precludes an index of abundance independent of returns to Mactaquac. Estimates of returns destined for Mactaquac but removed before reaching their goal were, with the improved surveillance by Conservation and Protection staff, presumed to be improved over those of 1986.

Failure to adequately document returns and removals results in the underestimation of the Saint John's production capacity and, in time, will contribute to the underestimation of future returns. Forecasts and corrected estimates of returns 1982 to 1987, presently suggest however that forecasts (000's) in 4 out of 6 (1SW) and 5 out of 6 (MSW) years have been higher than estimated returns (000's):

	1982		1983		1984		1985		1986		1987	
Returns	1SW	MSW	1SW	MSW	1SW	MSW	1SW	MSW	1SW	MSW	1SW	MSW
Forecast	19.2	16.8	15.8	16.2	14.9	10.0	17.5	15.5	9.5	13.4	13.1	18.0
Actual	14.3	11.8	11.3	8.4	13.0	14.7	10.8	14.8	16.5	11.3	17.1	8.0
Act/Forec(%)	75	70	72	52	87	147	62	95	174	84	129	45

Fortunately, the importance of annual forecasts have been down-played by the current 1984-1988 Management Plan. Deficiencies of recent assessments support the continuation of multi-year management plans based on general trends in stock status rather than on a specific assessment.

Ritter, J.A. Biological Sciences Branch, DFO Halifax, N.S., B3J 2S7

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Table 1. Estimated total returns of wild and hatchery 1SW and MSW salmon destined for above and below Mactaquac Dam on the Saint John River, N.B., 1987.

Sea-age	Components	Number of fish								
		Above Mactaquac			Below Mactaquac			Total		
		Wild	Hatch.	Total	Wild	Hatch.	Total	Wild	Hatch.	Total
1SW										
	Mactaquac counts	5,095	2,877	7,972	-	-	-	5,095	2,877	7,972
	Kingsclear catch[a]	184	96	280	-	-	-	184	96	280
	Angled MS below Mactaquac[b]	512	288	800	-	-	-	512	288	800
	By-catch[c]	118	67	185	109	48	157	227	115	342
	Returns to tribs. below Mactaquac	-	-	-	5,339	2,330	7,669	5,339	2,330	7,669
	Totals	5,909	3,328	9,237	5,448[d]	2,378[e]	7,826	11,357	5,706	17,063
MSW										
	Mactaquac counts	3,088	342	3,430	-	-	-	3,088	342	3,430
	Kingsclear catch[a]	1,010	110	1,120	-	-	-	1,010	110	1,120
	Angled MS below Mactaquac[b]	36	4	40	-	-	-	36	4	40
	By-catch[c]	218	24	242	151	9	160	369	33	402
	Returns to tribs. below Mactaquac	-	-	-	2,873	172	3,045	2,873	172	3,045
	Totals	4,352	480	4,832	3,024[d]	181[f]	3,205	7,376	661	8,037

a Estimated at 1,400 fish of which 1SW = 20%; MSW = 80%.
b Preliminary, where MSW removals equal 10% of catch estimated with 1SW exploitation rate.
c Proportions of 2% total 1SW returns and 5% total MSW returns.
d Based on 1970-1983 proportion of production below (App. 1), i.e., 0.48 for 1SW and 0.41 for MSW.
e Sum of the products of adjusted 1SW return rate to above Mactaquac and 38,387 smolts (1986) released below Mactaquac, reduced by those that went to Mactaquac (App. 2); 143,658 parr released in 1985 at Mactaquac x 0.0074 x 0.5 and 211,655 parr released in 1985 below Mactaquac x 0.0074 (see Marshall, MS 1987, for estimation of parr return rates).
f Product of adjusted MSW return rate for above Mactaquac and 56,992 smolts released below Mactaquac reduced by those that went to Mactaquac (App. 2).

Table 2. Estimated total number of 1SW and MSW returns to the Saint John River from hatchery-reared smolts released at[a] Mactaquac, 1974-1987.

Releases			Returns (1SW/MSW)								% return	
				Mactaquac								
Year	Smolts	Prop 1-yr	Year	Mtg ch	Dam	Kings-clear	Angled main SJ	By-catch	Comm-ercial	Total	Unadj	Adj
1974	337,281	0.00	1975	1,771	3,564	28	977	34		6,374	1.890	
75	324,186	0.06	76	2,863	4,831	219	1,129	32		9,074	2.799	
76	297,350	0.14	77	1,645	4,533	36	708	70		6,992	2.351	
77	293,132	0.26	78	777	1,779	49	369	70		3,044	1.038	
78	196,196	0.16	79	799	2,722	100	186	20		3,827	1.951	
79	244,012	0.09	80	3,072	6,687	335	640	59		10,793	4.423	
80	232,258	0.12	81	921	2,861	139	350	74	385	4,730	2.037	
81	189,090	0.08	82	828	1,464	64	267	21	202	2,846	1.505	1.445
82	172,231	0.06	83	374	857	39	69	11	95	1,445	0.839	0.776
83	144,549	0.22	84	476	828	36	63	48		1,451	1.004	0.976
84	206,462	0.28	85	454	1,288	82	128	66		2,018	0.977	0.920
1974-84	2,636,747									52,594	1.995	
85	89,051	1.00	86	64	635	53	93	17		862	0.968[b]	0.868
86	191,495	1.00	87	198	2,679	96	288	67		3,328	1.738	1.570
87	113,439	1.00	88									
1974	337,281		1976	310	1,313	392	267	20		2,302	0.683	
75	324,186		77	341	1,727	206	417	34		2,725	0.841	
76	297,350		78	223	1,728	368	165	50		2,534	0.852	
77	293,132		79	145	747	210	65	21		1,188	0.405	
78	196,196		80	302	1,992	506	146	46		2,992	1.525	
79	244,012		81	126	963	252	125	147	999	2,612	1.070	
80	232,258		82	88	640	462	181	50	110	1,531	0.659	
81	189,090		83	44	255	76	17	23	166	581	0.307	0.285
82	172,231		84	84	722	201	5	103		1,115	0.647	0.559
83	144,549		85	73	492	189	5	116		875	0.605	0.553
84	206,462		86	16	471	266	4	40		797	0.386[b]	0.346
1974-84	2,636,747									19,252	0.730	
85	89,051		87	4	338	110	4	24		480	0.539	0.453
86	191,495		88									
87	113,439		89									

[a] Includes returns from down-river stocking of smolts, 1981-1986; adjusted return rate removes downriver returns to Mactaquac (see App. 2).

[b] Corrected from Marshall (MS 1987) with finalization of angling and by-catch removals.

Table 3. Estimated homewater removals[a] of 1SW and MSW salmon destined for above and below Mactaquac Dam on the Saint John River, N.B., 1987.

Sea-age	Components	Number of fish								
		Above MActaquac			Below Mactaquac			Total		
		Wild	Hatch.	Total	Wild	Hatch.	Total	Wild	Hatch.	Total
1SW	Kingsclear Indians	184	96	280	-	-	-	184	96	280
	Angled									
	Tobique River	475	225	700		-	-	475	225	700
	Mainstem above Mact.	90	60	150		-	-	90	60	150
	Mainstem below Mact.	512	288	800		-	-	512	288	800
	Tribs below Mactaquac	-	-	-	811	354	1,165	811	354	1,165
	Trucked to Aroostook R.	0	57	57	-	-	-	0	57	57
	Hatchery broodfish	34	0	34	2	1	3	36	1	37
	Mortalities, etc.	1	10	11	0	0	0	1	10	11
	By-catch	118	67	185	109	48	157	227	115	342
	Totals	1,414	803	2,217	922	403	1,325	2,336	1,206	3,542
MSW	Kingsclear Indians	1,010	110	1,120	-	-	-	1,010	110	1,120
	Angled[b]									
	Tobique River	28	2	30	-	-	-	28	2	30
	Mainstem above Mact.	3	0	3	-	-	-	3	0	3
	Mainstem below Mact.	36	4	40	-	-	-	36	4	40
	Tribs below Mactaquac	-	-	-	45	3	48	45	3	48
	Trucked to Aroostook R.	1	0	1	-	-	-	1	0	1
	Hatchery broodfish	479	128	607	25	3	28	504	131	635
	Mortalities, etc.	28	3	31	4	0	4	32	3	35
	By-catch	218	24	242	151	9	160	369	33	402
	Totals	1,803	271	2,074	225	15	240	2,028	286	2,314

[a] Previous to significant federal and provincial input; wild: hatchery composition per estimated returns.
[b] 10% of angled MSW fish assumed to be lost from spawning escapement.

Table 4. Estimated homewater returns, removals and spawning escapement of 1SW and MSW salmon destined for above and below Mactaquac Dam, Saint John River, 1987.

Sea-age	Category	Number of fish						
		Above Mactaquac		Below Mactaquac		Total		
		Wild	Hatch.	Wild	Hatch.	Wild	Hatch.	Both
1SW								
	Homewater returns	5,909	3,328	5,448	2,378	11,357	5,706	17,063
	Homewater removals[a]	1,414	803	922	403	2,336	1,206	3,542
	Spawners	4,495	2,525	4,526	1,975	9,021	4,500	13,521
	Target spawners[b]	3,200		4,400				7,600
	Percentage of target spawners	219		148				178
MSW								
	Homewater returns	4,352	480	3,024	181	7,376	661	8,037
	Homewater removals[a]	1,803	271	225	15	2,028	286	2,314
	Spawners	2,549	209	2,799	166	5,348	375	5,723
	Target spawners[b]	4,400		5,700				10,100
	Percentage of target spawners	63		52				57

[a] Includes broodfish for Mactaquac FCS (Table 3).
[b] Excludes broodfish for Mactaquac FCS (Table 3).

Table 5. Adjusted Tobique River egg deposition[a]/100 m^2 (yr i & i+1) recruiting to total wild 1SW and MSW salmon which would have returned to Mactaquac in the absence of homewater removals in yr i+5 and i+6, resultant MSW:1SW salmon ratios, and forecast numbers of 1SW and MSW fish to Mactaquac in the absence of homewater removals in 1988.

Eggs/100 m^2		Recruits 1SW		Recruits MSW		MSW/
Years	Number	Year	Number	Year	Number	1SW
(1)	(2)		(3)		(4)	(5)
1965-66		1970	3,057	1971	4,715	1.54
1966-67		71	1,709	72	4,899	2.87
1967-68		72	908	73	2,518	2.77
1968-69	23.95	73	2,070	74	5,811	2.81
1969-70	40.58	74	3,656	75	7,441	2.04
1970-71	74.35	75	6,858	76	8,177	1.19
1971-72	122.34	76	8,147	77	9,712	1.19
1972-73	85.39	77	3,977	78	4,021	1.01
1973-74	81.66	78	1,902	79	2,754	1.45
1974-75	371.61	79	6,828	1980	10,924	1.60
1975-76	330.50	1980	8,482	81	5,991	0.71
1976-77	244.80	81	5,782	82	5,001	0.86
1977-78	288.96	82	4,958	83	3,447	0.69
1978-79	167.00	83	4,309	84	9,779	2.27
1979-80	239.74	84	8,311	85	10,436	1.26
1980-81	219.60	85	6,526	86	6,128	0.94
1981-82		86	7,904	87	4,352	0.55
1982-83		87	5,909	88	6,983[c]	
1983-84	183.20	88	6,054[b]			

[a] See App. 3, 4 and 5 for derivation and update of Marshall (MS 1987).

[b] Based on regression of 1SW returns to Mactaquac, 1973-1985, (col. 3) on adjusted egg deposition in Tobique River, 1968-1969 to 1980-1981, (col. 2):

$\log_e Y = 6.523 + 0.407 \log_e X$: n=13, r=0.70, p= 0.012

$Y_{1988} = 6,054$(AM): 95% C.L. = 4,748 to 7,719.

[c] Based on regression of MSW returns to Mactaquac, 1971-1987, (col. 4) on 1SW returns to Mactaquac, 1970-1986, (col. 3):

$\log_e Y = 5.026 + 0.433 \log_e X$; n=17, r=0.63, p= 0.007

$Y_{1988} = 6,983$(AM); 95% C.L. = 5,649 to 8,631.

Table 6. Forecasts of hatchery 1SW and MSW returns to the Saint John River, 1988, as estimated from numbers of various juveniles released at or above (At) and below (Bl) Mactaquac and estimated return rates.

Release					Returns in 1988			
					1SW		MSW	
Year	Loc.	Stage	Number	Return rates	To Mact	Bl Mact	To Mact	Bl Mact
1987	At	1-yr smolt	113,439	0.01193[a]	1,353			
1987	Bl	1-yr smolt	39,445	0.01193 @ 0.25 & 0.75	118	353		
1986	At	1-yr parr	89,115	(0.30x0.025x0.5)[b]		334		
1986	Bl	1-yr parr	14,337	0.30x0.025		108		
1985	At	Fall fing.	289,000	0.08[c] x 0.03	694			
1985	Bl	Fall fing.	82,400	0.08 x 0.03		198		
1985	Bl	Unfed fry	623,000	(0.01x0.6)[d] x 0.025		94		
1986	At	1-yr smolt	191,495	0.00453[e]			867	
1986	Bl	1-yr smolt	38,387	0.00453 @ 0.36 & 0.64			63	111
1985	At	1-yr parr	143,658	0.30 x 0.025 x 0.5				539
1985	Bl	1-yr parr	211,665	0.30 x 0.025				1,587
1984	At	Fall fing.	123,600	(0.05x0.6)[f] x 0.025			93	
1984	Bl	Fall fing.	294,200	(0.05x0.4)[f] x 0.025				147
Totals					2,165	1,087	1,023	2,384

a Arcsin mean 1986-1987 adjusted return rate; proportions above and below (App. 2)
b Parr-smolt survival of 0.30, smolt-to-1SW return rate of 0.025; mainstem discount factor (all approx. 0.0074 value used in 1986 returns).
c Age-0+ to age-2 smolt survival and smolt-to-1SW return rate of 0.030.
d Age-0+ (unaccel.) to age-2 smolt survival, proportion age-2's and 1SW return rate of 0.025.
e 1987 return rate.
f Fall fingerling (unaccel.) to age-3 smolt survival rate and proportion age 3's.

Table 7. Summary of the 1988 salmon forecast for the Saint John River, New Brunswick (95% C.L. in parentheses).

Requirement	1SW			MSW		
	Wild	Hatch.	Total	Wild	Hatch.	Total
Above Mactaquac	6,054 (4,748-7,719)	2,165	8,219	6,983 (5,649-8,649)	1,023	8,006
Target escpm.[a]			3,200			4,400
Surplus			5,019			3,606
Below Mactaquac	5,588	1,023	6,611	4,853	2,384	7,237
Target escpm.[a]			4,400			5,700
Surplus			2,211			1,537
Total	11,642	3,188	14,830	11,836	3,407	15,243
Target escpm.[a]			7,600			10,100
Surplus			7,230			5,143

[a] Excludes broodfish for Mactaquac Fish Culture Station.

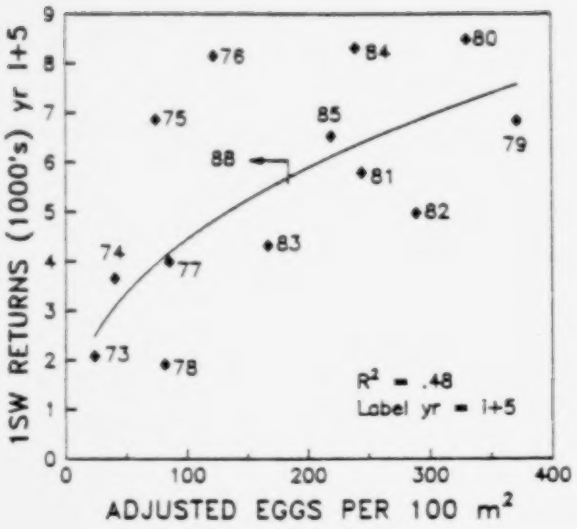

Fig. 1. Saint John, 1SW recruitment above Mactaquac.

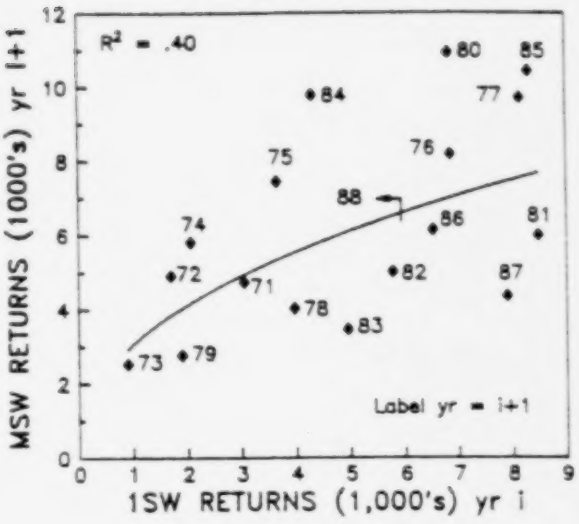

Fig. 2. Saint John, MSW recruitment above Mactaquac.

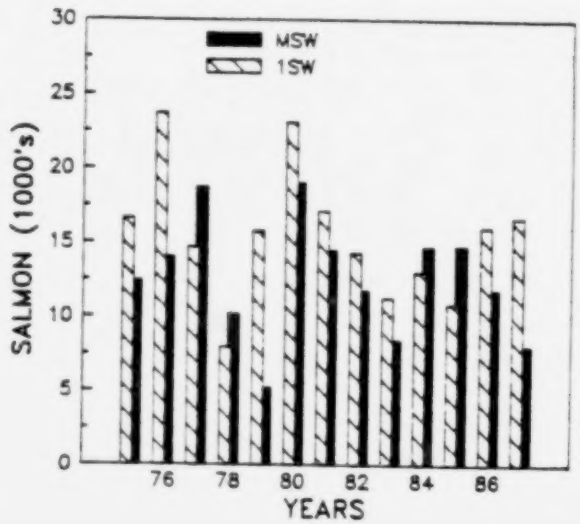

Fig. 3. Saint John, total hatchery and wild returns.

App. 1 Estimated total returns of wild 1SW and MSW salmon originating above and below Mactaquac Dam, Saint John River, 1970-1987.

Sea-age	Year	(1) Mact. count	(2) Kings-clear	(3) Angled main SJ	(4) Trib. Returns Bl. Mact.	(5) Comm. fishery Total	(6) Above	(7) Below	(8) By-catch Total	(9) Above	(10) Below	Total returns (proportions) Above	Below	Total
1SW														
	1970	2,874		78	2,732	200	105	98	3			3,057	2,830	5,887
	71	1,592		60	3,194	166	57	109	0			1,709	3,303	5,012
	72	784		83	1,420				107	41	66	908	1,486	2,394
	73	1,854		179	2,390				81	37	44	2,070	2,434	4,504
	74	3,389	27	214	4,502				59	26	33	3,656	4,535	8,191
	75	5,725	45	1,052	3,366				54	36	18	6,858	3,384	10,242
	76	6,797	307	1,014	6,456				52	29	23	8,147	6,479	14,626
	77	3,507	28	403	3,670				76	39	37	3,977	3,707	7,684
	78	1,584	43	231	2,912				113	44	69	1,902	2,981	4,883
	79	6,234	228	331	5,081				62	35	27	6,828	5,108	11,936
	80	7,555	378	503	3,790				67	46	21	8,482	3,811	12,293
	81	4,571	222	428	6,221	730	470	260	194	91	103	5,782	6,584	12,366
	82[a]	3,932	171	466	4,492	1,482	352	1,130	79	37	42	4,958	5,664	10,622
	83[a]	3,623	164	207	4,151	1,091	283	808	68	32	36	4,309	4,995	9,304
Mean												4,475(.52)	4,093(.48)	8,568(1.00)
	84[a]	7,353	317	351	2,825				387	290	97	8,311	2,825	11,136
	85[a]	5,331	389	460	1,874				443	346	97	6,526	1,971	8,497
	86[a]	6,347	547	852	7,150				304	158	146	7,904	7,296	15,200
	87[b]	5,095	184	512	5,339				227	118	109	5,909	5,448	11,357
MSW	1970	2,449		59	2,935	6,934	3,204	3,749	19			5,712	6,684	12,396
	71	2,235		89	1,060	3,473	2,391	1,082	0			4,715	2,142	6,857
	72	4,831		62	2,277				9	6	3	4,899	2,280	7,179
	73	2,367		91	4,350				165	60	105	2,518	4,455	6,973
	74	4,775	569	459	3,575				13	8	5	5,811	3,580	9,391
	75	6,200	739	446	2,758				77	56	21	7,441	2,779	10,220
	76	5,511	1,646	950	3,528				101	70	31	8,177	3,559	11,736
	77	7,247	864	1,489	6,217				184	112	72	9,712	6,289	16,001
	78	3,034	645	263	3,559				151	79	72	4,021	3,630	7,651
	79	1,993	561	152	1,240				70	48	22	2,754	1,262	4,016
	80	8,157	2,069	533	5,037				244	165	79	10,924	5,116	16,040
	81	2,441	639	282	2,857	4,983	2,291	2,692	669	338	331	5,991	5,880	11,871
	82	2,262	1,626	592	2,989	2,440	359	2,081	332	162	170	5,001	5,240	10,241
	83[a]	1,712	512	98	2,421	2,651	986	1,665	309	139	170	3,447	4,256	7,703
Mean												5,795(.59)	4,082(.41)	9,877(1.00)
	84[a]	7,011	1,934	41	3,236				1,061	793	268	9,779	3,530	13,309
	85[a]	6,391	2,337	53	2,763				2,156	1,655	501	10,436	3,264	13,700
	86[a]	3,656	2,134	32	4,045				519	306	213	6,128	4,258	10,386
	87[b]	3,088	1,010	36	2,873				369	218	151	4,352	3,024	7,376

[a] Update of Marshall (MS 1987)
[b] Preliminary

App. 2. Smolt release information background to the calculation of 'adjusted' return rates for smolts released at Mactaquac and adjustment of hatchery (1982-1987) and wild (1982-1985) returns below Mactaquac. A:- Numbers of tag returns and return rate to Mactaquac from smolts released at and below Mactaquac 1983-1986; B:- Total smolts released below Mactaquac which originated from Mactaquac F.C.S. (also numbers released at Mactaquac) and C:- proportionate contribution by smolts released below Mactaquac to and below Mactaquac and D:- Calculation of adjusted return rate for 1986 smolts returning as 1SW fish in 1987.

A.

Return year	1SW At Mactaquac Tags	Tagged	Rate	1SW Below Mactaquac Tags	Tagged	Rate	Relative rate	MSW At Mactaquac Tags	Tagged	Rate	MSW Below Mactaquac Tags	Tagged	Rate	Relative rate
1984	64	10,000	.0064	7	13,000	.0005	1:11.85							
1985	114	19,988	.0057	26	15,996	.0016	1: 3.56	30	10,000	.0030	11	13,000	.0007	1: 3.55
1986	97	15,900	.0061	13	11,952	.0011	1: 5.55	24	19,988	.0012	10	15,996	.0006	1: 1.92
1987	113	15,901	.0071	19	4,975	.0038	1: 1.87	41	15,900	.0026	9	11,952	.0008	1: 3.42

B.

Year	Smolts released Below	At
1981	44,918[a]	189,090
1982	80,535	172,231
1983	48,706	144,549
1984	46,126	206,462
1985	56,992	89,051
1986	38,387	191,495
1987	39,445	113,435

[a] plus 21,200 from Minto.

C.

Year	1SW At	1SW Below	MSW At	MSW Below
1984	.08	.92	-	-
1985	.28	.72	.28	.72
1986	.18	.82	.52	.48
1987	.52	.48	.30	.70
$\bar{x}$(arcsin)	.25	.75	.36	.64

D.

- 191,495x1.87 from A (above)+38,387=396,483 smolt equivs.
- releases below represent 9.68% of 396,483 smolt equivs. and 3,328 x 0.0968 or 322 of 1SW fish at Mactaquac.
- adjusted Mactaquac return rate=(3,328-322)/191,495 =0.0157
- returns below estimated at (38,387x0.0157)-322= 281 1SW fish.

App. 3. Freshwater age and number of 1SW fish (A) counted at Mactaquac fish passage facilities, Saint John River, 1976-1987, and (B) that would have returned to Mactaquac had they not been exploited within the river, 1976-1987.

Fresh-water age	Number of 1SW fish											
	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986[a]	1987[b]
A												
2	3,962	922	391	3,166	2,214	1,280	794	2,348	4,140	1,264	3,196	2,513
3	2,658	2,545	1,160	2,974	4,986	2,861	2,902	1,264	3,132	3,913	3,001	2,349
4	177	39	33	94	355	430	236	11	81	144	150	233
5										5		
6										5		
Total	6,797	3,506	1,584	6,234	7,555	4,571	3,932	3,623	7,353	5,331	6,347	5,095
B												
2	4,749	1,046	469	3,468	2,486	1,619	1,001	2,793	4,679	1,548	3,980	2,915
3	3,186	2,887	1,393	3,257	5,598	3,619	3,659	1,503	3,540	4,790	3,737	2,724
4	212	44	40	103	398	544	298	13	91	176	187	270
5										6		
6										6		
Total	8,147	3,977	1,902	6,828	8,482	5,782	4,958	4,309	8,311	6,526	7,904	5,909

a Revised from Marshall (MS 1987) according to updates on sport and bycatch.

b Preliminary.

App. 4. Number of wild 1SW salmon and proportion of age 2:1's of the total that would have returned to Mactaquac for the 1969-1982 year-classes (numbers of 1SW fish from Table 10, Marshall MS 1984, and App. 3)

Year-class (i)	Number at age of 1SW returns to Mactaquac				Prop. 2:1's of total
	2:1 (i+3)	3:1 (i+4)	4:1 (i+5)	Total	
1968		690	41		
1969	127	451	37	615	0.207
1970	1,578	1,901	68	3,547	0.445
1971	1,718	4,465	212	6,395	0.269
1972	2,325	3,186	44	5,555	0.419
1973	4,749	2,887	40	7,676	0.619
1974	1,046	1,393	103	2,542	0.411[a]
1975	469	3,257	398	4,124	0.114[a]
1976	3,468	5,598	544	9,610	0.361
1977	2,486	3,619	298	6,403	0.388
1978	1,619	3,659	13+6	5,296	0.306
1979	1,001	1,503	91+6	2,601	0.385
1980	2,793	3,540	176	6,509	0.429
1981	4,679	4,790	187	9,656	0.485
1982	1,548	3,737	270	5,555	0.279
1983	3,980	2,724			
1984	2,915				

[a] Influenced by low survival of 1977 smolt-class.

App. 5. Number of eggs/100 m^2 deposited in the Tobique River, 1968-1983, and derivation of weighted number of eggs contributing to annual returns of wild 1SW fish at Mactaquac, 1973-1985 and 1988 (explanation in Penney and Marshall MS 1984).

Egg deposition		Proportion age at smoltification[a]		Eggs/100 m^2 contributing to 1SW fish		Total wt'd egg contrib/100 m^2 to 1SW fish @ Mact. (yr)
Year	Number	Age 2	Age 3	Yr i	Yr i+1	
1968	5.7	0.207				
			0.793		4.55	
1969	43.6	0.445		19.40		23.95 (1973)
			0.555		24.20	
1970	60.9	0.269		16.38		40.58 (1974)
			0.731		44.52	
1971	71.2	0.419		29.83		74.35 (1975)
			0.581		41.37	
1972	130.8	0.619		80.96		122.33 (1976)
			0.381		49.84	
1973	86.5	0.411		35.55		85.39 (1977)
			0.589		50.95	
1974	269.4	0.114		30.71		81.66 (1978)
			0.886		238.69	
1975	368.2	0.361		132.92		371.61 (1979)
			0.639		235.28	
1976	245.4	0.388		95.22		330.50 (1980)
			0.612		150.18	
1977	309.2	0.306		94.62		244.80 (1981)
			0.694		214.58	
1978	193.2	0.385		74.38		288.96 (1982)
			0.615		118.82	
1979	112.3	0.429		48.18		167.00 (1983)
			0.571		64.12	
1980	362.1	0.485		175.62		239.74 (1984)
			0.515		186.48	
1981	118.7	0.279		33.12		219.60 (1985)
			0.721		85.58	
1982	139.8					
1983	69.4					
			0.640[b]		44.42	
1984	385.5	0.360[b]		138.78		183.20 (1988)

[a] Derived from App. 3 and 4.

[b] Mean (n=14) calculated with angular transformation.

App. 6. Returns of wild and hatchery 1SW and MSW to above and below Mactaquac Dam, Saint John River, 1970-1987

Year	Wild				Hatchery				Total returns	
	Above		Below		Above		Below			
	1SW	MSW	1SW	MSW	1SW	MSW	1SW	MSW	1SW	MSW
1970	3,057	5,712	2,830	6,684						
1971	1,709	4,733	3,303	2,142						
1972	908	4,899	1,486	2,280						
1973	2,070	2,518	2,434	4,455						
1974	3,656	5,811	4,535	3,580						
1975	6,858	7,441	3,384	2,779	6,374	2,210			16,616	12,430
1976	8,147	8,177	6,479	3,559	9,074	2,302			23,700	14,038
1977	3,977	9,712	3,707	6,289	6,992	2,725			14,676	18,726
1978	1,902	4,021	2,981	3,630	3,044	2,534			7,927	10,185
1979	6,828	2,754	5,108	1,262	3,827	1,188			15,763	5,204
1980	8,482	10,924	3,811	5,116	10,793	2,992			23,086	19,032
1981	5,782	5,991	6,584	5,880	4,730	2,612			17,096	14,483
1982	4,958	5,001	5,664	5,240	2,846	1,531	841		14,309	11,772
1983	4,309	3,447	4,995	4,256	1,445	581	516	145	11,265	8,429
1984	8,311	9,779	2,825	3,530	1,451	1,115	435	298	13,022	14,722
1985	6,526	10,436	1,971	3,264	2,018	875	305	193	10,820	14,768
1986	7,904	6,128	7,296	4,258	862	797	406	77	16,468	11,260
1987[a]	5,909	4,352	5,448	3,024	3,328	480	2,378	181	17,063	8,037

[a] Preliminary

App. 7. Estimates of commercial (incl. by-catch), sport (DNRE bright fish) and Native landings of 1SW and MSW salmon (000's) on the Saint John River, 1949-1987.

Year	Commercial[a]			Sport			Native			Grand Total
	1SW	MSW	Total	1SW	MSW	Total	1SW	MSW	Total	
1949	1.5	16.1	17.6							
1950	1.1	12.4	13.5							
1951	1.6	17.9	19.5							
1952	1.1	12.1	13.2							
1953	1.6	14.9	16.5							
1954	0.9	9.5	10.4							
1955	0.8	5.5	6.3							
1956	0.6	4.9	5.5							
1957	0.8	6.9	7.7							
1958	1.2	13.8	15.0							
1959	2.1	14.3	16.4							
1960	1.0	10.6	11.6							
1961	0.8	9.5	10.3							
1962	0.5	5.5	6.0							
1963	0.6	4.2	4.8							
1964	0.9	9.4	10.3							
1965	1.5	17.8	19.3							
1966	1.5	18.9	20.4							
1967	0.7	9.4	10.1							
1968	0.7	7.3	8.0							
1969	0.3	2.5	2.8	1.5	0.6	2.1				4.9
1970	0.4	5.4	5.8	1.3	1.3	2.6				8.4
1971	0.3	2.6	2.9	1.2	0.7	1.9				4.8
1972	0.1	0.1	0.1	0.9	1.6	2.5				2.6
1973	0.1	0.2	0.3	1.3	1.5	2.8				3.1
1974	0.1	0.1	0.1	2.0	2.5	4.5	0.1	0.6	0.6	5.2
1975	0.1	0.1	0.2	2.5	1.7	4.2	0.1	0.7	0.8	5.2
1976	0.1	0.1	0.2	4.7	2.8	7.5	0.5	2.0	2.5	10.2
1977	0.1	0.2	0.3	4.3	4.4	8.7	0.1	1.1	1.2	10.2
1978	0.2	0.2	0.4	1.7	2.2	3.9	0.1	1.0	1.1	5.4
1979	0.1	0.1	0.2	3.3	0.8	4.1	0.3	0.8	1.1	5.4
1980	0.1	0.3	0.4	4.7	5.4	10.1	0.8	2.6	3.4	13.9
1981	1.4	6.8	8.2	4.1	2.0	6.1	0.4	0.9	1.3	15.6
1982	1.8	2.9	4.7	3.4	2.0	5.4	0.2	2.1	2.3	12.4
1983	1.3	3.1	4.4	2.5	1.1	3.6	0.2	0.6	0.8	8.8
1984[b]	0.4	1.2	1.6	2.8	0.3	3.1	0.4	2.1	2.5	7.2
1985[b]	0.5	2.3	2.8	3.5	0.4	3.9	0.5	2.5	3.0	9.7
1986[b]	0.3	0.6	0.9	3.7	0.3	4.0	0.6	2.4	3.0	7.9
1987[bc]	0.3	0.4	0.7	2.8	0.1	2.9	0.3	1.1	1.4	5.0

a Closure 1972 to 1980 incl., and 1984 to 1987 incl.
b Includes 10% of estimated sport-caught MSW releases.
c Preliminary.